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APPLICATION NUMBER: *60/424,606*
FILING DATE: *November 07, 2002*
RELATED PCT APPLICATION NUMBER: *PCT/US03/34186*

By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

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PTO/SB/16 (8-00)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Carl V.	Nelson	Rockville, Maryland

☐ *Additional inventors are being named on the ____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

Moving Belt Metal Detector

CORRESPONDENCE ADDRESS

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OR

☒ Firm *or* Individual Name: **Office of Patent Counsel**

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 5 ☐ CD(s), Number

☐ Drawing(s) *Number of Sheets* ☐ Other (specify)

☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☒ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number 01-2218

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($): **$80.00**

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☐ No.

☒ Yes, the name of the U S Government agency and the Government contract number are: U.S. Army CECOM contract no. DAAB15-00-C-1008

Respectfully submitted,

SIGNATURE Ernest R. Graf Date 11/6/02

TYPED or PRINTED NAME Ernest R. Graf

REGISTRATION NO. *(if appropriate)* 41,043

TELEPHONE (240) 228-5639

Docket Number: 1885-1008

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

P19SMALL/REV05

JHU/APL Docket No. 1885-1008 PRV

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of : Carl V. Nelson

For: Moving Belt Metal Detector

Assistant Commissioner for Patents
Box Provisional Application
Washington, D.C. 20231

EXPRESS MAIL CERTIFICATE

"Express Mail" label number **EL685618637US**

Date of Deposit: 7 November 2002

I hereby certify that the following attached provisional application as identified above consisting of:

1. Postcard receipt
2. Provisional Application for Patent Cover Sheet (in duplicate) (1 page)
3. Provisional Application (5 pages)

is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to Assistant Commissioner for Patents, Box Provisional Application, Washington, D.C. 20231.

Barbara A. MacBride

Docket No. 1885-100
Title: Moving Belt Metal Detector
Inventor: Carl V. Nelson

Moving Belt Metal Detector

Carl V. Nelson

August 17, 2002

Background

For efficient and fast detection of landmines and unexploded ordnance (UXO), metal detectors (MD) are sometimes mounted to vehicles. Typically, the vehicle-mounted MD is used to clear roads and paths for advancing troops or to clear bombing ranges for military base cleanups. The military base cleanup effort by itself is estimated to cost $200 Billion over the next 300 years just in the US using conventional metal detection and clearing technology. Conventional MD that are mounted to vehicles all have one thing in common: they use electromagnetic induction (EMI) coil metal detectors fixed in place on the vehicle. The MD are fixed in place either in front of the vehicle, under the vehicle or behind the vehicle. Vehicle-mounted MD to date have just used modified handheld MD technology. A robotic application is obvious.

Need

A MD has a region of sensitivity that is directly related to the size of the transmitter and receiver coils. Basically, the MD is sensitive to metal only near the coil. A MD also has a time constant that relates the amount of time that the MD must integrate (perform some type of signal processing) the detected signal so as to discriminate the metal from the background. This is especially true for the small metal in plastic landmines. This time constant is relatively fast when a human is walking and searching for landmines. However, for tactical military reasons, a vehicle MD system must travel as fast a possible. In a number of references, the US Army has stated that speeds up to 10 m/s (~20 MPH) are desirable. The relatively fast time constant of the handheld MD now is relatively slow for a vehicle-mounted MD. Consider a MD that is a modified version of a handheld MD. It has a typical time constant of 0.2 s and a diameter of 0.2 m. A first order estimate of the speed the MD could be moved over the ground is then:

$$\text{Speed} = 0.2\ \text{m} / 0.2\ \text{s} = 1\ \text{m/s}$$

This is walking speed and is clearly a relatively slow speed compared to what the US Army has requested.

For metal clutter discrimination, the MD must dwell over a small metal target longer than the time it takes for metal target detection. This is necessary because the signal must be at least 10 times the noise for proper discrimination algorithms to work effectively. Extra time is needed to integrate the signal and reduce the noise. This time may be as long as 0.5 to 2 seconds for small plastic landmines. Since the number of metal clutter targets in a typical environment can range for 100 to 10,000 time the number of landmines, it is important to have the time to collect data for target discrimination.

In addition to the military and humanitarian demining applications, a need existing in process control for the detection of unwanted metal in material on a conveyor belt (e.g., food processing) or flowing material in a pipe (chemical plant).

Invention

The present invention relates to a MD that is ideally suited to a moving vehicle application or other moving platform. The Moving Belt Metal Detector (MBMD) is an array individual EMI coil metal detectors mounted to or part of or embedded into a flexible track (e.g., tank track) or flexible belt. The MD are connected via a transmitter and receiver bus arrangement that connects the power and signals of the MD to the vehicle via a commutation system. A number of different implementations are possible. A simple application or a single tracked vehicle will demonstrate the invention.

Figure 1 and 2 are block diagrams of the MBMD:

1. A linear array of MD are laid end-to-end along the track- e.g., embedded in track/belt segments.
2. For clarity, the transmitter and receiver coils are separated - one could use the same coil for both transmit and receive.
3. A series of wires (typically two or more) form a "bus" to the transmitter and receiver
4. The transmitter bus conveys power to the coil for excitation purposes
5. The receiver bus conveys signals from the receiver coil to the data collection system.
6. Bus interfaces are located between the different buses. The interfaces control the transmitter power timing and receiver coil data transfer to the data collection and control system.
7. The linear array of transmitter/receiver coil pairs are mounted on a track or other flexible structure that forms a continuous loop.
8. The loop is placed over at least two wheels that are attached to the vehicle.
9. The individual MDs can operated in a time-division multiplex way so as not to interfere with each other. Various timing schemes are possible depending on whether the metal detectors use frequency or time domain technology.
10. Alternatively, a single large loop transmitter could be fixed to the vehicle and be used to excite metal targets for all of the receiver coils mounted on the moving belt/track. For this case, the receivers need not be time-division multiplexed.
11. A commutation device attached to the wheel (e.g., inductive coupling) connects the buses to the vehicle
12. An alternative to the commutation device would have the receivers use a wireless technology to convey the data to the data collection system.
13. The data collection system performs detection and classification functions.
14. The receiver interface could have a detector coil pre-amplifier and metal detection and classification signal circuitry. In which case the data transfer speeds would not be very great via the receiver bus.
15. The vehicle has locomotive power, MD power, and MD data collection and control system.
16. The loop motion, with embedded MD array, is now synchronized with the vehicle motion. This places the MD array over the same point on the ground for a length of time that is related to the loop length along the portion that is closest to the ground.

17. The loop could also form part of the locomotive track of the vehicle, in which case the loop would be in contact with the ground.
18. The loop could be in "light" (e.g., non-load condition so as not to set off landmine) contact with the ground in order to place the MD as close to the target as possible. Since the signal strength from a MD is a strong function of distance between the MD and metal, placing the MD on the ground is the optimal location for detection of small metal.

Now consider a MBMD with an active detection length of 2 m. The MD detection coil size can still be nominally the size of a conventional MD coil but its size is really not the governing factor for the detection speed: It's the active detection length. The detection coil is now in stationary contact with a point over the ground. Consider the case of just metal detection using the above MD time constant of 0.2 s. The approximate speed of the MD over the ground is now:

$$\text{Speed} = 2\ \text{m} / 0.2\ \text{s} = 10\ \text{m/s}$$

The MBMD can achieve the speed goal of the US Army with a conventional MD technology utilized in this novel method.

At slower speeds, the MBMD can be still useful for discrimination of metal clutter. If we use a 1 second dwell time for the above length, we have:

$\text{Speed} = 2\ \text{m} / 1\ \text{s} = 2\ \text{m/s}$

a possibility acceptable speed considering now we have the ability to do target classification on the fly. As MD discrimination processing time improves (lowers), the speed of the vehicle can increase.

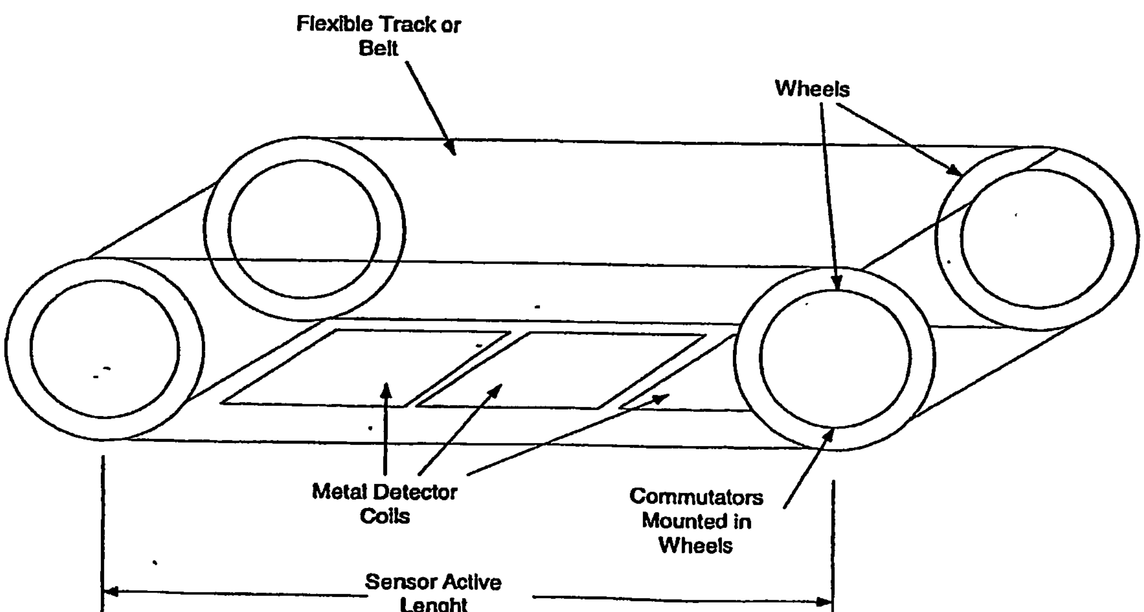
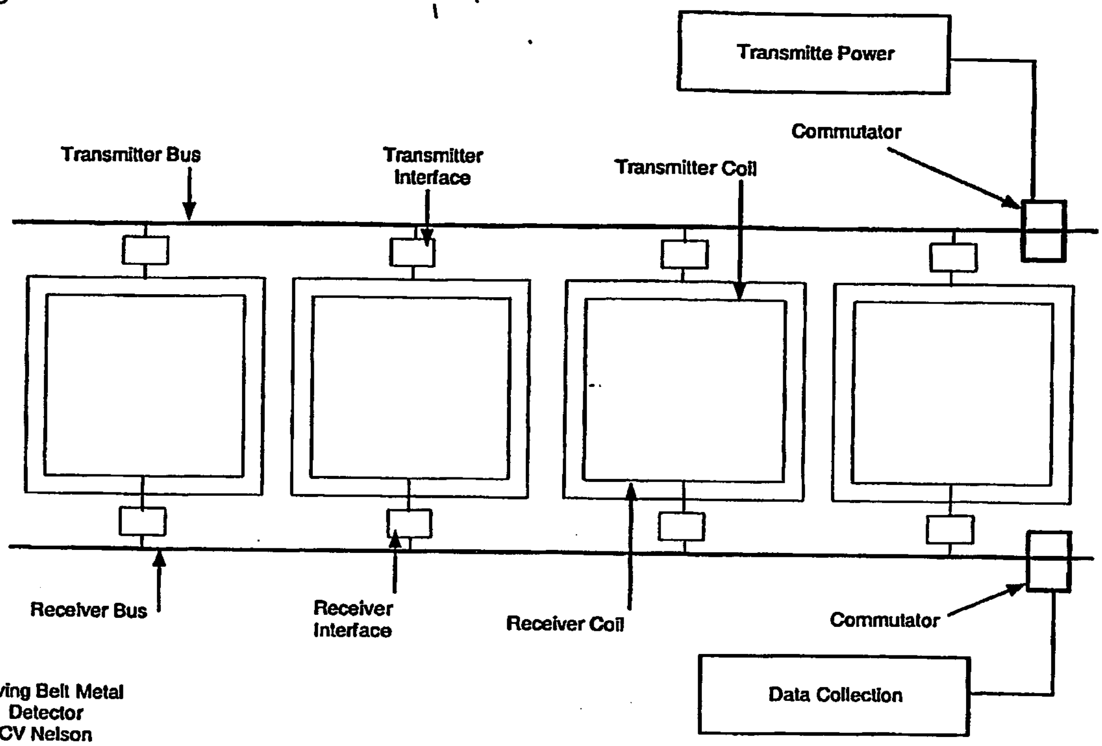


Figure 1



Moving Belt Metal
Detector
CV Nelson
8-17-02

Figure 2